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International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : B66B 11/06

A1

(11) International Publication Number: WO 99/43599

(43) International Publication Date: 2 September 1999 (02.09.99)

(21) International Application Number: PCT/US99/03650

(22) International Filing Date: 19 February 1999 (19.02.99)

(30) Priority Data:

09/031,108	26 February 1998 (26.02.98)	US
09/163,676	30 September 1998 (30.09.98)	US
09/218,990	22 December 1998 (22.12.98)	US

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(81) Designated States: BR, CN, IN, JP, KR, RU, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

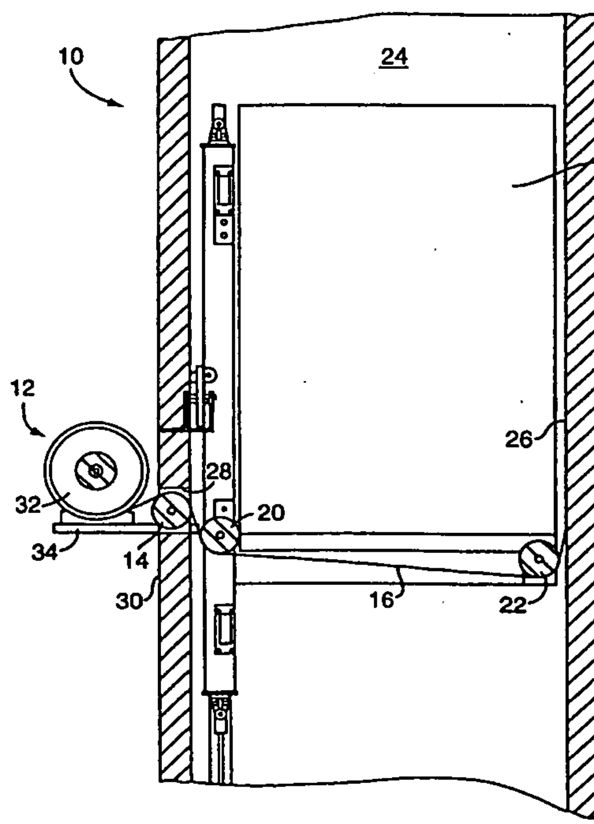
Published

With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: DRUM DRIVE ELEVATOR USING FLAT BELT

(57) Abstract

An elevator system (10) includes an elevator car (18) supported for vertical movement on a belt (16) having an end fixed to the hoistway (26) and the other end wound about a drum (32) of a drum drive (12). When the belt (16) is wound or unwound about the drum (32), the elevator car (18) is raised or lowered, respectively.



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DRUM DRIVE ELEVATOR USING FLAT BELT

TECHNICAL FIELD

The present invention relates to elevator systems and, more particularly, to a drum drive elevator system that requires minimal installation and operation space and that eliminates the potential of inadvertently driving past the top terminal.

BACKGROUND OF THE INVENTION

Known drum drive elevator systems typically involve "cotton reel" type drum and lifting rope arrangements where the rope is wound onto the drum with successive turns such that each length of rope is placed adjacent to the prior length to form a single layer of wound rope. Such systems are usually limited to single layer rope winding because of safety and rope life considerations. In situations where the elevator car must travel over a large rise, the length of the drum required to accommodate single layer rope winding becomes impractical. Because of the length of the drum in such instances, large variations in the rope path occur as the rope is wound along the drum. This may cause difficulty in the placement of guidance sheaves and may result in changing direction of forces imposed on the elevator car thereby affecting ride quality.

In typical elevator systems, lifting force on an elevator car is delivered from a sheave located above the car. Without additional means of control, the lifting force could continue to be delivered until the elevator car impacts either the ceiling of the hoistway or the sheave. Thus, there exists the potential in conventional elevator systems having the drive sheave or drum located overheard that the elevator car may be accidentally driven through the top terminal. Special precautions are ordinarily required to ensure that drive force is disabled when the elevator car moves beyond the top terminal level. In traction elevator systems, for example, a deceleration zone and safety equipment such as a rope brake are required, adding cost and space consumption.

Conventional drum and traction elevator systems usually require a large machine room to accommodate the overhead machine and components, including safety features. It is desirable to eliminate the need for a large machine room and its associated costs and building structure requirements.

OBJECTS AND SUMMARY OF THE INVENTION

It is an object of the present invention to provide a drum elevator system that requires minimal machine room space. It is a further object to provide a drum elevator system that has inherent safety features to eliminate the potential of driving through the top terminal. These and other inherent objects are achieved by the invention as described below.

The present invention elevator system utilizes a drum and rope system that allows multiple layers of rope winding around the drum. The arrangement eliminates the problems described above associated with rope path variation and ride quality, while increasing the practical limit for rise height. The present invention elevator system also ensures that the lifting force on the elevator car is reduced to zero at a short distance past the upper terminal level, thereby eliminating the over-rise problem described above. This loss of lifting force is inherently controlled by the sizing and spatial arrangement of the drum, car sheaves, a diverter sheave and the fixed hitch point of the belt. In the present invention the vertical positions of the drum and the fixed hitch point define the limit of the highest achievable vertical position of the elevator car. This feature eliminates the need for speed limiting or other safety features.

The present invention elevator system requires only a small machine room that can be located on the top terminal floor, avoiding the need for a separate structure and special building requirements. There is no requirement for hoistway space to accommodate a counterweight, as is required with conventional traction systems.

In another embodiment of the present invention, an elevator system utilizes a single drum drive positioned at the bottom of the hoistway, or in the hoistway pit, and is adapted to simultaneously wind two traction belts. Each traction belt is attached to and supports one side of the elevator car. One end of each belt is attached to the elevator car, and the other end of each belt is attached to the drive drum for selective winding to retract or release belt length, thereby controlling vertical movement of the elevator car. The positioning of the drum drive in the pit eliminates the need for a machine room or external structure for mounting the drive, while allowing sufficient space for the double-wound drum when the elevator car is in a raised position.

These and other advantages are apparent from the description provided below.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a partial, schematic, side cross-sectional view of an elevator system according to the present invention, showing the elevator car near a top position.

Fig. 2 is a view as shown in Fig. 1, in which an elevator car is at the absolute top position.

Fig. 3 is a partial, schematic side view of an elevator car assembly according to the present invention.

Fig. 4 is a partial, schematic perspective view of an elevator car assembly according to Fig. 3.

Fig. 5 is a partial, schematic perspective view of an elevator system of according to a second embodiment of the present invention.

FIG. 5a is an enlarged, fragmentary view of the drive drum.

FIG. 6 is a sectional view of one of the flat ropes.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to Fig. 1, the present invention elevator system (10) includes a drum drive assembly (12), a diverter sheave (14), a belt (16), and an elevator car (18) having two underside sheaves (20, 22). The elevator car (18) and associated sheaves (20, 22) are positioned for vertical movement within a hoistway (24). The belt (16) is fixed at one end to a first hoistway wall (26). The other end of the belt (16) passes through an opening (28) in a second hoistway wall (30) and engages a drum (32) component of the drum drive (12) in a wrap-around fashion. The diverter sheave (14) is mounted in the second hoistway wall (30).

The drum drive assembly (12) is mounted on a base (34) that is fixed relative to the hoistway. The assembly (12) includes a conventional motor (not shown) and a drum (32) adapted to selectively rotate in either direction. The belt (16), preferably a flat belt or flat rope, is wound successively around the drum (32). The terms "flat ropes" or "flat belts" as used herein refer to ropes or belts having an aspect ratio greater than one, where the aspect ratio is defined as the ratio of the rope or belt width to thickness. The belt or rope

should be sufficiently thin to enable successive winding around the drum so that a rope or belt of sufficient length to enable a desired range of lift height can be used. Conventional controls are used to activate and direct power to the motor which, in turn, imparts torque to cause the drum (32) to rotate thereby winding or unwinding the belt (16).

In operation, the elevator car (18) can be lowered from the raised position shown in Fig. 1 by activating the motor to turn the drum (32) counterclockwise to unwind the belt (16) from the drum (32). As the belt (16) is let out over the diverter sheave (14) and underneath the two car-mounted sheaves (20, 22), the force of gravity acting on the elevator car (18) forces the car (18) to move downward while being supported by the belt (16). Conventional guide or track means (not shown) are used to guide the car movement as it descends or ascends. The first end of the belt (16) remains fixed to the first hoistway wall (26). When the desired car (18) position is reached, the drum (32) is stopped. In order to raise the elevator car (18), the same procedure is followed with the drum (32) being caused to rotate in the opposite direction.

A safety feature of the present invention for preventing the elevator car (18) from overrunning or from rising higher than the upper terminal is dependent upon the sizing and positioning of the fixed end of the belt (16) and the drum (32). While the preferred embodiment is directed to a drum drive, it is possible to implement the presently described features in a system using a traction drive.

Referring to Fig. 2, with the drum (32) placed at the top floor level and the fixed end of the belt (16) located at approximately top floor level, the elevator car (18) can be driven only up to a point where the bottoms of the car sheaves (20, 22) are level with a plane connecting the top of the diverter sheave (14) and the fixed point of the belt (16). Even with infinite tension on the belt (16) the elevator car (18) cannot travel above this point. Thus, the diameter and placement of the diverter sheave (14), the diameter and placement of the car sheaves (20, 22), and the position of the fixed belt (16) point limit the vertically upward travel of the elevator car (18).

The car sheaves (20, 22) are offset with respect to vertical height for the reasons explained below. As the elevator car (18) travels upward, the center of the first car sheave (20) passes the center of the diverter sheave (14). As a result, the tension necessary to maintain upward travel increases, as the

load of the car (18) formerly supported by the first car sheave (20) is transferred to the second car sheave (22).

As the center of the first car sheave (20) passes the center of the diverter sheave (14), and the tension necessary to maintain upward travel of the car (18) begins to increase, the net lifting force will be reduced in a cosine like manner, reducing from one hundred percent of the belt tension when the center of the first car sheave (20) is level with the center of the diverter sheave (14), to zero when the bottom of the first car sheave (20) is level with the top of the diverter sheave (14). Movement of the second car sheave (22) past the fixed hitch point of the belt (16) has a similar effect on net lifting force from the second car sheave (22), but the net force reduction occurs over a movement of only half the sheave (22) diameter.

Thus, the rate of deceleration of the elevator car (18) is controlled by the diameter and placement of the diverter sheave (14), the diameter and placement of the car sheaves (20, 22), and the placement of the fixed hitch point of the belt (16).

The arrangement of components of the present invention elevator system (10) imposes minimal requirements on the building structure. All vertical forces are supported by the hoistway (24). Horizontal forces from belt tension are supported by the top terminal floor. No special machine or hitch beams are required. The total mass that needs to be transported to, installed in and supported by the building structure is less than half of that associated with a conventional traction elevator system. Only minimal top overrun clearance is necessary, and no overhead machine room is needed. The present invention elevator system can be used in a smaller hoistway space than a traction system that requires room for a counterweight.

The construction of the car (18) and its sheave components used with the preferred embodiment as described herein is described with respect to Figs. 3 and 4. In the side view of Fig. 4 there is disclosed a pair of cantilever supports (36, 38) that support the car (18) from underneath at the car floor (48) and that extend from a pair of vertical frame members (40, 42). Not all of the car walls (44, 46) are shown, nor the roof, in order to allow illustration of other components. The car (18) may be made with a single entrance or with double entrances. The vertical frame members (40, 42) may be provided with conventional safety and guide components (not shown).

The vertical frame members (40, 42) are limited in height so as to not extend above the top of the car (18). The car walls (44, 46), floor (48), and roof are formed from a thin structural material, such as an aluminum sandwich panel, to enable them to be self-supporting. Such construction enables minimum wall thickness with maximum floor area. The drum drive assembly (12) is located on the top floor at the side of the hoistway (24) or in a small machine room (not shown) at the same level as the top floor. In order to ensure that vertical loads are passed directly to the hoistway wall (30), the diverter sheave (14) is positioned in an opening (28) in the wall (30) enabling the diverter sheave (14) to extend slightly into the hoistway (24). The diverter sheave (14) is positioned as closely as possible to the floor level to minimize overrun distance.

The hitch point for the end of the belt (16) is on the wall (26) opposite the drum drive assembly (12). The hitch point is located vertically so that, when the elevator car (18) is at the top floor level, a substantially straight line can be drawn through points connecting the top of the diverter sheave (14), the bottom of each car sheave (20, 22), and the hitch point. This is the maximum vertical position attainable by the car (18).

Because the car (18) is lifted essentially through its center of mass, there are only small loads placed on guides, guide rails, or the car structure except for loads caused by use of safety equipment that may be utilized.

The drum drive assembly (12) is preferably a single unit including a motor, a gearbox, a brake, a drum, a diverter pulley, a drive, a controller and a governor.

While the preferred embodiment utilizes a diverter sheave (14) and two car sheaves (20, 22), it is possible to implement a system within the scope of the present invention in which no diverter sheave is used and in which a different number of car sheaves such as, for example, one sheave is used or in which no car sheaves are used. The position of the car sheave or sheaves on the elevator car is not necessarily limited to the bottom of the elevator car and may be, for example, on the top of the elevator car.

A second embodiment of the present invention is directed to the elevator system (200) shown in Fig. 5. The system (200) includes a hoistway (202), an elevator car (204), a drive assembly (206) including a drive drum (208) located at the bottom (210) or in the pit of the hoistway (202), a pair of drive belts (212, 214) , a pair of counterweights (216, 218) attached to the

drive belts (212, 214), a pair of suspension sheaves (220, 222), and two sets of diverter pulleys (224, 226). The drive drum (208) receives both belts (212, 214) simultaneously so that they wrap and unwrap over each other. By sharing a single drive drum (208), the two belts (212, 214) are easily synchronized and the space required for the drive assembly (206) is minimal. By positioning the drum (208) below in the hoistway (202), there is sufficient space to accommodate the increased diameter of the drum (208) when the belts (212, 214) are fully wound and the elevator car (204) is in the fully raised position. The diverter pulleys (224, 226) maintain the necessary positioning of the belts (212, 214) to enable simultaneous winding around the same drum (208).

A principal feature of the present invention is the flatness of the ropes used in the above described elevator system. The increase in aspect ratio results in a rope that has an engagement surface, defined by the width dimension "w", that is optimized to distribute the rope pressure. Therefore, the maximum rope pressure is minimized within the rope. In addition, by increasing the aspect ratio relative to a round rope, which has an aspect ratio equal to one, the thickness "t1"of the flat rope (see Fig. 6) may be reduced while maintaining a constant cross-sectional area of the portions of the rope supporting the tension load in the rope.

As shown in Fig. 6, the flat ropes 722 include a plurality of individual load carrying cords 726 encased within a common layer of coating 728. The coating layer 728 separates the individual cords 726 and defines an engagement surface 730. The load carrying cords 726 may be formed from a high-strength, lightweight non-metallic material, such as aramid fibers, or may be formed from a metallic material, such as thin, high-carbon steel fibers. It is desirable to maintain the thickness "d" of the cords 726 as small as possible in order to maximize the flexibility and minimize the stress in the cords 726. Steel fibers having such diameter improve the flexibility of the cords and the rope. By incorporating cords having the weight, strength, durability and, in particular, the flexibility characteristics of such materials into the flat ropes, the maximum rope pressure may be maintained within acceptable limits.

The coating layer 728 is formed from a polyurethane material, preferably a thermoplastic urethane, that is extruded onto and through the plurality of cords 726 in such a manner that each of the individual cords 726 is restrained against longitudinal movement relative to the other cords 726.

Other materials may also be used for the coating layer if they are sufficient to meet the required functions of the coating layer: wear, transmission of loads to the cords and resistance to environmental factors.

As a result of the configuration of the flat rope 722, the rope pressure may be distributed more uniformly throughout the rope 722. Because of the incorporation of a plurality of small cords 726 into the flat rope elastomer coating layer 728, the pressure on each cord 726 is significantly diminished over prior art ropes. Cord pressure is decreased at least as $n^{-1/2}$, with n being the number of parallel cords in the flat rope, for a given load and wire cross section. Therefore, the maximum rope pressure in the flat rope is significantly reduced as compared to a conventionally roped elevator having a similar load carrying capacity.

While the preferred embodiment of the present invention has been herein described, it is acknowledged that variation of the aforedescribed embodiment may be undertaken without departing from the scope of what is presently claimed.

I CLAIM :

1) An elevator system comprising

an elevator car ;

a drum machine ; and

a belt engaged with said elevator car and with said drum machine, such that said drum machine can be operated to move said elevator car.

2) An elevator system according to claim 1, further comprising

at least one belt-engaging sheave attached to said elevator car to engage said belt.

3) An elevator system according to claim 1, wherein

said belt has a first end fixed with respect to a hoistway at a vertical position defining the uppermost position to which said elevator car can move.

4) An elevator system according to claim 3, wherein

said drum machine receives a second end of said belt in a manner such that said belt can be selectively retracted into or released from said drum machine to effect raising or lowering of said elevator car.

5) An elevator system according to claim 2, further comprising

at least one diverter sheave fixed relative to a hoistway and positioned between said drum machine and said belt.

6) An elevator system comprising

an elevator car adapted to travel along a path ;

a drive machine positioned adjacent to said path ;

a rope engaged with said elevator car and with said machine ;

a hitch point at which a first end of said rope is fixed, and wherein the relative locations of the drive machine and hitch point prevent overtravel of the car.

7) An elevator system according to claim 6, wherein

said hitch point is located on a wall of a hoistway in which said elevator car resides.

8) An elevator system according to claim 6, further comprising

at least one sheave attached to said elevator car and being adapted to engage said belt so that said elevator car is supported by said belt through said sheave.

9) An elevator system according to claim 6, wherein

said drive machine is a drum drive machine.

10) An elevator system according to claim 6, wherein

said drive machine is a traction drive machine.

11) An elevator system comprising

an elevator car ;

a drive assembly including a drive drum ; and

a pair of drive belts, each having one end fixed to said elevator car and each having the other end fixed to said drive drum, whereby said elevator car is suspended by said belts and is selectively moved by activating said drive drum.

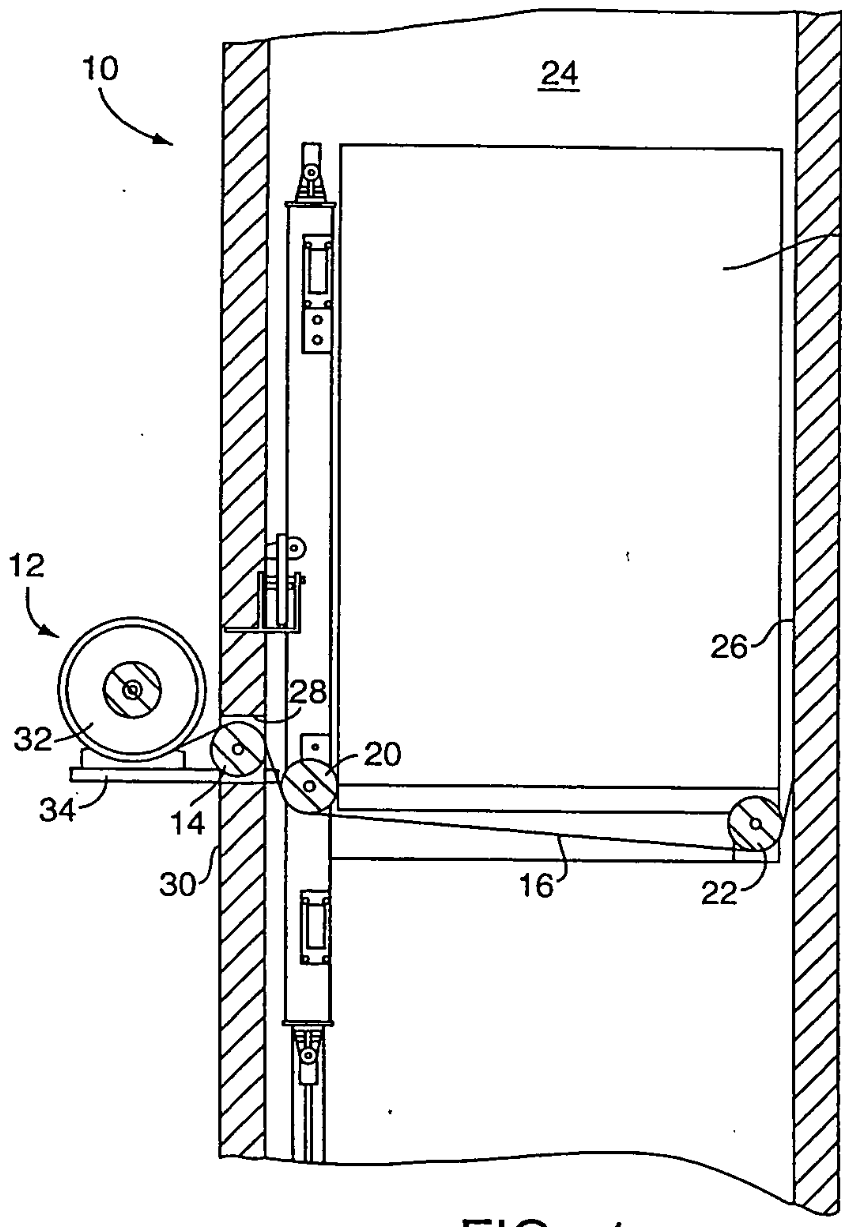

FIG. 1

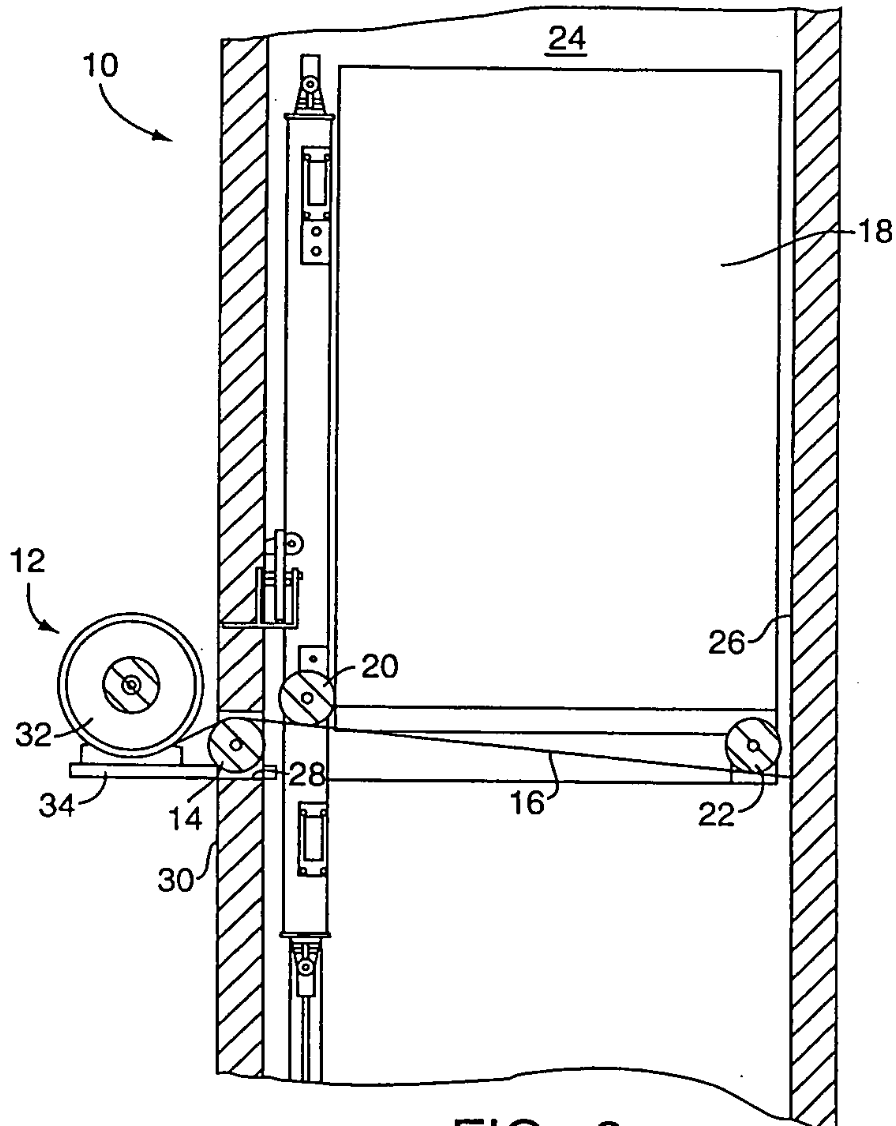

FIG. 2

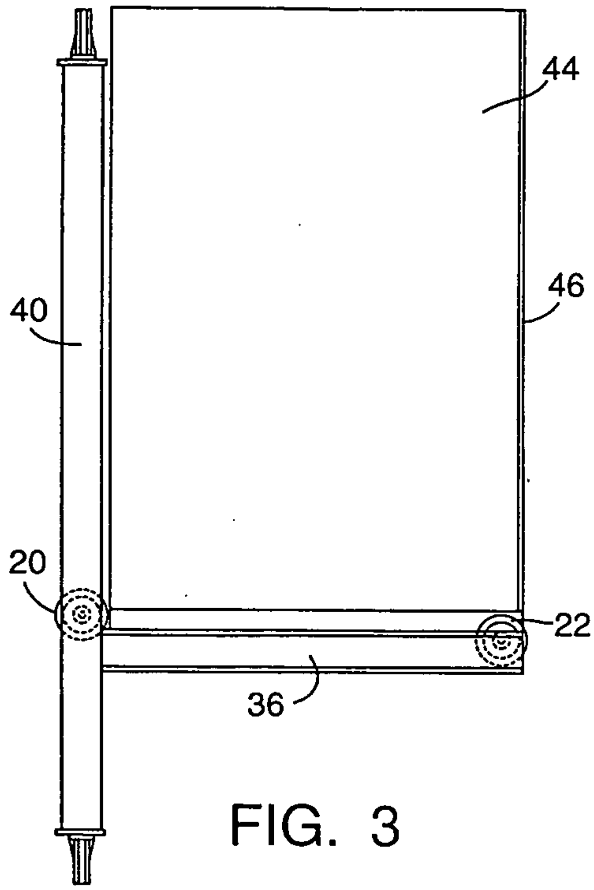

FIG. 3

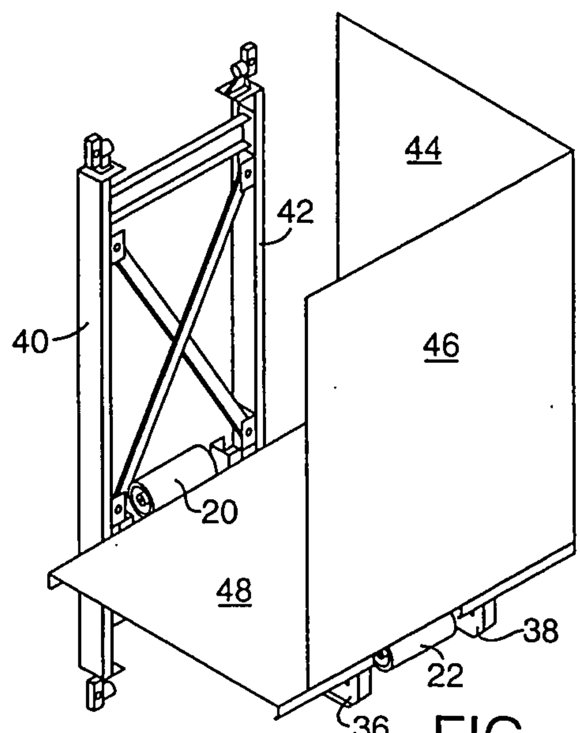

FIG. 4

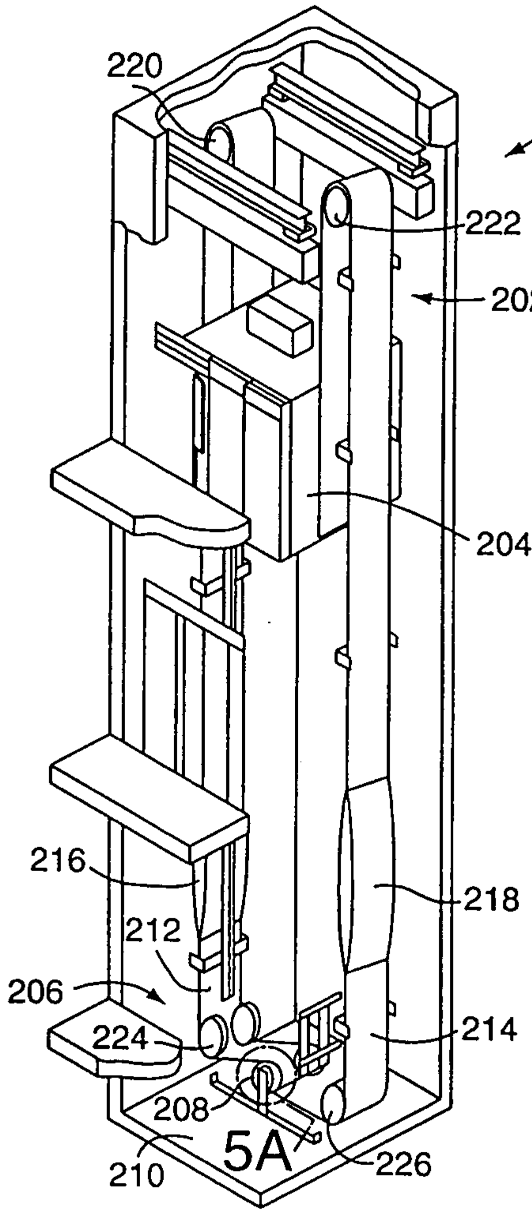

FIG. 5

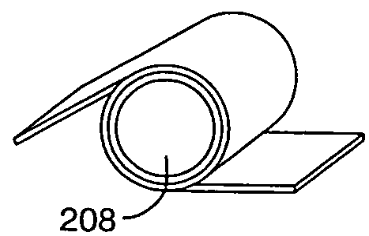

FIG. 5A

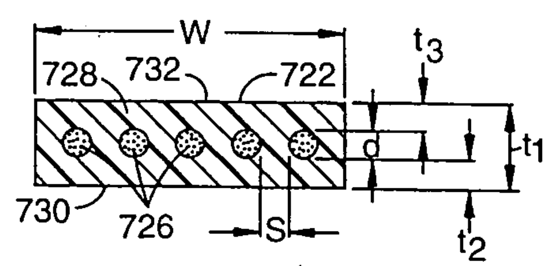

FIG. 6

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 99/03650

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B66B11/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B66B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	US 3 910 383 A (FRIEDL VLADIMIR) 7 October 1975 see abstract	1
Y	see figures	2-5,8
A		6,11
Y	CONTACTOR: "Electric lifts - A Practical Treatise on their Construction Operation and Maintenance" August 1942 , GEORGE NEWNES LIMITED , LONDON XP002103802	2-10
A	see page 23, paragraph 2 see figure 18	1,11
Y	EP 0 688 735 A (KONE OY) 27 December 1995 see abstract; figure 4	6,7,9,10

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
4 June 1999	23/06/1999

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INTERNATIONAL SEARCH REPORT

International Application No
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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X	DATABASE WPI Section PQ, Week 9020 Derwent Publications Ltd., London, GB; Class Q38, AN 90-153541 XP002103803 & SU 1 518 277 A (BLOKHIN A V) , 30 October 1989 see abstract ---	11
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Information on patent family members

International Application No
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